

Claims

1. Apparatus for supplying refrigerant fluid to a cooling device, said apparatus comprising:

5 an arrangement of valves for controlling fluid flow to and from said cooling device; and

a control unit configured to control said arrangement of valves in:

(i) a first operating mode in which said refrigerant 10 fluid flows in a first direction through said cooling device for generating a cooling effect in said cooling device; and

(ii) a second operating mode in which said refrigerant fluid flows at least momentarily in an opposite second direction through said cooling device for backflushing said 15 cooling device.

2. The apparatus of claim 1, wherein in said second mode, an at least momentary pressure differential is created across said cooling device to cause said refrigerant fluid 20 to flow in said second direction.

3. The apparatus of claim 2, wherein said pressure differential is greater than 300 psi.

25 4. The apparatus of claim 2, further comprising first and second fluid conduits for communicating with said coupling device, and wherein said control unit is configured in said second operating mode to control said arrangement of valves to create a head of pressure directly or indirectly in at 30 least said second conduit, and to vent pressure from said first conduit during or after creating said head of pressure.

5. The apparatus of claim 4, wherein said control unit is further configured to control the arrangement of valves in said first operating mode to supply refrigerant fluid to
5 said first conduit and to vent fluid from said second conduit.

6. The apparatus of claim 4, wherein said control unit is configured to control said arrangement of valves to vent
10 said first conduit after creating said head of pressure, and wherein said head of pressure is created in said second conduit by a third operating mode of supplying said refrigerant fluid through said first conduit and said cooling device to said second conduit, and blocking venting
15 of fluid from said second conduit.

7. The apparatus of claim 6, wherein said third operating mode is a thaw mode for heating said cooling device following a cooling operation.
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8. The apparatus of claim 1, wherein said first operating mode is a cooling mode of said cooling device, and wherein said second operating mode is a post-cooling mode subsequent to said cooling mode.
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9. The apparatus of claim 2, wherein said control unit is configured to perform said second operating mode after each performance of said first operating mode as part of a combined cycle.
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10. Apparatus for supplying refrigerant fluid to a cooling device, said apparatus comprising:

a first valve for controlling fluid flow to said cooling device; and

a control unit configured to generate a pulse modulated control signal for controlling said first valve, wherein
5 said pulse modulated signal is effective to control said first valve in a partly open condition.

11. The apparatus of claim 10, wherein said pulse modulated control signal is a pulse width modulated signal.

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12. The apparatus of claim 11, wherein said first valve is configured to open to an extent responsive to a duty ratio of said pulse width modulated signal.

15 13. Apparatus for supplying refrigerant fluid to a cooling device, said apparatus comprising:

a first valve for controlling fluid flow to said cooling device; and

a control unit configured to generate a control signal
20 for controlling an extent of opening of said first valve,

wherein said control unit is configured, in response to a command to open said first valve, to generate said control signal to open said valve gradually over an interval of time, whereby a pressure of said refrigerant gas supplied to
25 said cooling device increases gradually.

14. The apparatus of claim 13, wherein said control signal is a pulse modulated signal.

30 15. Apparatus for supplying refrigerant fluid to a cooling device, said apparatus comprising:

an arrangement of valves for controlling fluid flow to and from said cooling device; and

a control unit configured to control said arrangement of valves in at least a first mode of operation for generating cooling in said cooling device, and a second mode of operation for generating heating in said cooling device; said control device comprising a storage device for storing data defining a program sequence of at least one cycle of said first and second modes, and said control unit being configured to execute said program sequence.

16. The apparatus of claim 15, further comprising an input device for inputting a command to said control unit, wherein said control unit is responsive to said command to begin execution of said program sequence.

17. The apparatus of claim 16, wherein said input device comprises a foot-switch.

20 18. The apparatus of claim 15, wherein said storage device is configured to store a plurality of selectable program sequences.

19. Apparatus for supplying refrigerant fluid to a cooling device, said apparatus comprising:

an arrangement of valves for controlling a flow of said refrigerant fluid to and from said cooling device;

a flow rate sensor for sensing a flow rate of said refrigerant fluid and for generating a flow rate signal; and

30 a control unit responsive to said flow rate signal and configured to control said arrangement of valves.

20. The apparatus of claim 19, wherein said flow rate sensor is coupled to a low pressure side of said cooling device.

5 21. The apparatus of claim 19, wherein said control unit is configured to detect an occurrence of a blockage in said cooling device when said flow rate signal indicates an abnormally small flow rate of said refrigerant fluid.

10 22. The apparatus of claim 21, wherein said control unit is configured to perform an unblocking operation in response to detection of a blockage.

15 23. The apparatus of claim 22, wherein said unblocking operation is a backflush of said refrigerant fluid through said cooling device.

20 24. The apparatus of claim 19, wherein said control unit is configured to adjust a pressure of said refrigerant fluid supplied to said cooling device in response to the flow rate signal.

25 25. Apparatus for supplying a refrigerant fluid to a cooling device, the apparatus comprising:

a fluid supply conduit for receiving refrigerant fluid from a supply source;

first and second coupling conduits for communicating with said cooling device;

30 a first valve coupled between said fluid supply conduit and said first coupling conduit for selectively applying fluid pressure to said first coupling conduit;

a second valve coupled between said fluid supply conduit said second conduit for selectively applying fluid pressure to said second coupling conduit;

5. a third valve coupled between said first coupling conduit and a vent for selectively venting said first coupling conduit independently of said second coupling conduit;

10 a fourth valve coupled between said second coupling conduit and a vent for selectively venting said second coupling conduit independently of said first coupling conduit.

26. The apparatus of claim 25, further comprising a flow resistance coupled in series with said second valve between 15 said fluid supply conduit and said second conduit.

27. The apparatus of claim 25, further comprising a flow rate sensor coupled in series with the fourth valve between said second coupling conduit and said vent.

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28. The apparatus of claim 27, wherein said flow rate sensor is coupled between said fourth valve and said vent.

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29. The apparatus of claim 25, wherein said apparatus is configured to operate in a cooling mode for supplying refrigerant fluid in a forward direction through said cooling device, wherein said first valve and said fourth valve are open, and said second valve and said third valve are closed.

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30. The apparatus of claim 25, wherein said apparatus is configured to operate in a heating mode in which a head of

pressure is created directly or indirectly in each of said first and second supply conduits, wherein at least one of said first and second valves is open, and said third valve and said fourth valve are closed.

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31. The apparatus of claim 25, wherein said apparatus is configured to operate in a backflushing mode in which a head of pressure is backflushed from said second conduit through said cooling device to said first conduit, wherein said 10 first valve and said fourth valve are closed, and said third valve is open.

32. The apparatus of claim 25, wherein said first and second valves are normally closed valves, and said third and 15 fourth valves are normally open valves.

33. A method of operation of an apparatus for supplying refrigerant fluid to a cooling device, the method comprising:

20 controlling an arrangement of valves for controlling fluid flow to and from said cooling device, in:

(i) a first operating mode in which said refrigerant fluid flows in a first direction through said cooling device for generating a cooling effect in said cooling device; and

25 (ii) a second operating mode in which said refrigerant fluid flows at least momentarily in an opposite second direction through said cooling device for backflushing said cooling device.

30 34. A method of operation of an apparatus for supplying fluid refrigerant to a cooling device, the method comprising:

generating a pulse modulated command signal indicative of a commanded extent of valve opening; and

applying said pulse modulated command signal to a first valve configured for controlling refrigerant fluid flow to
5 said cooling device, to open said valve to said commanded extent.

35. A method of operation of an apparatus for supplying refrigerant fluid to a cooling device, the method
10 comprising:

providing data representing a programmed sequence of operating modes of said apparatus, said operating modes including a cooling mode and a heating mode; and

executing said program sequence automatically by
15 advancing from one mode to a next mode in a manner defined by the programmed sequence.

36. A method of operation of an apparatus for supplying fluid refrigerant to a cooling device, the method
20 comprising:

sensing a flow rate of said refrigerant fluid; and
controlling, in response to said sensed flow rate, an arrangement of valves configured to control fluid flow to and from said cooling device.